Net!Works White Paper on
"Economic impact of the ICT sector"

Executive Summary
The new European Union framework research program Horizon 2020 for the financial period 2014 to 2020 is currently under preparation. With respect to the overall limited funding budget different sectors are investigated and they have to provide arguments on their economic impact and importance for Europe. Therefore, this paper provides information from the ICT and in particular the communications networks perspective.

This paper is describing economic aspects of the ICT sector in a global context. The global ICT market is huge, where Europe has a share of about 25%. However, the European market is stagnating compared to other regions. Studies have shown that the availability of broadband access has positive impacts on GDP growth and employment. Therefore, the availability of broadband access is essential for a positive economic development. User penetration and traffic are growing, which offer a high potential for the ICT industry to deploy communication networks. However, the limited available frequency spectrum and economic conditions for the investment for system deployment versus charging models provides economic challenges for the sector and requires an investment friendly environment.

Europe made progress in the deployment of broadband systems in the last years. However, Europe is still lagging behind other regions, which may reduce competitiveness compared to other regions.

The research environment in Europe offers means for cooperation between different stakeholders in the precompetitive domain. It is essential that Horizon 2020 takes into account the interests of stakeholders on research topics and the implementation of the program. In addition, a sufficiently high budget should be allocated to Horizon 2020, because research and innovation are major means to overcome the current economic crises.

Value creation in Europe in the communications network domain is increasingly based on research, innovation and development as well as knowledge and IPR generation. It should be the objective of European policy to strengthen this sectors compared to classical manufacturing of equipment, because this enables to create and maintain competitive jobs in Europe.
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1. Introduction

Today communication networks are essential for all areas and sectors of our societies and economies in developed and emerging countries. They are bringing people together worldwide and enable global cooperation. Private activities, most business processes and public administrations are based on the availability of reliable communication networks.

Such systems have a long history. Electrical communication systems (telegraph lines) were introduced in the first half of the 19th century. In the second half of the 19th century wireline telephone systems revolutionised long-distance communication. In the last decades data communication became possible with more and more broadband communication systems. Today the global Internet is a major driving force for the further development of communication networks. The widespread introduction of mobile and wireless communication more than 20 years ago is providing access to global communication to a fast increasing number of users, which helps emerging economies to grow and to improve life of their citizens.

Many services and applications are based on the Internet. Critical infrastructures like energy, gas, water, traffic, health etc. are becoming increasingly dependent on information and communication technology (ICT). Therefore, ICT is also a critical infrastructure for societies and economies. It is a key enabling technology for all sectors and is making other processes and the use of resources more efficient.

Therefore, communication networks (fixed and mobile systems) are continuously further developed towards more capacity, higher throughput rates and improved Quality of Service (QoS). With respect to critical infrastructures there is an increasing demand for very high availability (99.999 % corresponding to 5.26 minutes downtime per year) and reliability of such systems. Privacy and data security is a very strong concern for users and governments.

Research, development, deployment and operation of communication networks and in particular in cooperation with other critical infrastructures require a wide know-how base in Europe in order to meet societal requirements and to guarantee secure and reliable service provision to users. Maintaining and improving the know-how base in Europe requires research on all areas of such systems.

This paper is describing economic aspects of the ICT sector in a global context. Section 2 is briefly describing the global ICT market and overall economic developments. The economic impact of the availability of broadband access is shown in Section 3. User penetration and traffic growth (Section 4) demonstrates the potential for the communication networks sector. However, the available frequency spectrum (Section 5) and economic conditions for the investments for system deployment versus charging models provides economic challenges and requires an investment friendly environment (Section 6). Section 7 describes the status of broadband deployment in Europe. The research environment in Europe offers means for cooperation between different stakeholders in the precompetitive domain (Section 8). Value creation in Europe in the communications network domain is addressed in Section 9. Section 10 provides conclusions.
2. Global ICT market and economic developments

2.1 ICT market

The communications technology sector is relying on international – and ideally on global – standards in order to ensure interoperability of systems and economy of scale to reduce cost. In particular mobile and wireless communications is requiring global interoperability as much as possible to serve roaming users and devices and to ensure Quality of Service (QoS). Major global standards and systems in mobile and wireless communications as well as in optical communications are based on European collaborative research projects [1]. Results of respective projects were used for consensus building between organisations to prepare future standards, which are also cooperating in international standards organisations. This ensures the exploitation of results and economy of scale with affordable cost for communication service providers and end customers.

Communication networks are a key enabling technology for all sectors of society and economy to provide connectivity. Increasingly, many infrastructures like electrical energy systems, gas and water networks, traffic, health and other societal challenges depend on reliable and highly available communication networks. According to Bitkom [2] the worldwide ICT market volume increased in 2010 by nearly 5 % to about 2500 Billion €. The biggest ICT market is USA with a market share of 28.7 % (Figure 1). For example Germany with 5.1 % global market share is No. 4 after the USA, Japan and China. Europe with a market share of 25.2 % is in a similar order of magnitude like the US. According to GSMA [3, p. 3] the mobile communications market in Europe reached a total revenue of 174 billion € in 2010, which is comparable to the aerospace industry and larger than pharmaceuticals.

![World market share for ICT in 2010 without consumer electronics](image)

**Figure 1** World market share for ICT in 2010 [2]

Industry from Europe is serving the global ICT market. Country and regional specific data (Figure 2) on market size and development are available in [4]. The global ICT market was also affected in 2009 by the financial crisis. It is slightly increasing again since 2009. However, the European ICT market is basically stagnating. Its market value is still below the figure of 2008. The Asia-Pacific region and the USA with a similar market size like Europe and in particular the BRIC (Brazil, Russia, India and China) countries show bigger growth rates, which offer promising economic prospects for industry from Europe. European industry has a significant share in this business. Industry from Europe has to be present in these markets to benefit from that growth with respect to increasing productivity in order to maintain employment and business.

However, there is fierce global competition in particular from Asian manufacturers. Research and development is essential to maintain the position of industry in Europe to be on the forefront of the technology development.
Figure 2  ICT market in selected countries and regions [4]
* Data and forecast are based on information available as of May 2011
In particular markets like complex devices for optical communications the European market share in the global market corresponds to 45 %. However, production of components is increasingly also shifted towards Asia [5, pp. 48]. The Photonics European Technology Platform prepared a SWOT-analysis of the optical communications sector, which shows similar conditions like in mobile and wireless communications [5, pp. 52].

2.2 Contribution of the Internet economy

The ICT market is increasingly be driven by the Internet. According to [6, p. 25] the following key messages are important to understand this impact:

- The European Internet Economy is estimated at 498 B€ in 2010, corresponding to 4.1 % of EU27 GDP. This proves that the Internet generates an important contribution to EU growth.
- The value of the Internet economy by country varied in 2010 from 118 B€ in Germany, to 6 B€ in Poland; in terms of contribution to GDP, the UK leads with 6.2 %, followed by Germany with 4.7 % and France with 4.6 %.
- The variations of the value of the Internet economy by country are influenced by the level of eReadiness (higher intensity and sophistication of Internet use and availability of enabling factors such as broadband are correlated with higher value); by the strength of the consumer market in each national economy; by the structure of the economy in each country (countries with a strong services economy have an edge).
- The lion’s share of the European Internet economy is generated by end-user spending for goods and services over the Internet (BtoC – Business to Customer), which grew from 273 to 323 B€ in 2010, increasing its share of the total Internet economy from 63 % to 65 %. In other words, consumption, rather than investments, drives the growth of the Internet economy.
- The penetration of Internet buyers on the population is expected to continue to grow fast across the EU, reaching 56 % in the EU27 by 2014, corresponding to 282 million buyers.
- Thanks to these growth trends, and if the general economic climate remains positive, BtoC eCommerce will grow in the EU27 from 323 B€ in 2010 to 566 B€ in 2014, with an average growth rate of 15 %.
- Business to Business (BtoB) eCommerce, also known as Supply chain eCommerce, cannot be measured as a contribution to GDP, because it involves intermediate transactions between organizations. But its relevance for global supply chains and business processes is even higher.
- According to IDC estimates, the value of BtoB eCommerce reached 1,874 B€ in 2010, with a 19 % growth on 2009. This is almost 6 times as much as the value of BtoC. BtoB eCommerce is projected to grow to 2,746 B€ in 2014, with an average growth rate of 10 %.
- BtoB is strongly correlated with company size, with a much higher presence in large enterprises. Therefore, it is not surprising to find Germany as the largest market, followed by the UK and France. Italy’s manufacturing base explains why its BtoB market is much larger than that of Spain. But BtoB is also growing fast in countries such as Poland.
- The need for global standards and business demand for ever more sophisticated innovation will play a key role in BtoB diffusion.
- European BtoC eCommerce represented the largest share (46 %) of worldwide BtoC eCommerce in 2010, and this share is expected to increase to 48 % by 2014. China’s share is also expected to grow, while the US’ one will shrink.
- The US instead dominate worldwide BtoB. European BtoB eCommerce represented the second largest share of worldwide BtoB in 2010: 29 % of 6,422 B€, against 36 % for the US. Both shares will decrease by 2014, while China’s and especially the Rest of the World’s ones will increase substantially.
Figure 3 shows the contributions from different stakeholders to the Internet economy [6, p. 28; 7, p. 58]. The BtoC component provides the biggest contribution.

![Figure 3](image1)

**Figure 3** Internet economy, value and share of EU GDP, B€ and % of total spending, 2009 and 2010 [6, p. 28; 7, p. 58]

The share of the Internet economy in different European countries is different (Figure 4). In particular in more service-oriented economies the share in GDP is bigger [6, p. 31].

![Figure 4](image2)

**Figure 4** Internet Economy for the main EU Countries, Share of Country GDP, 2010, Source: IDC 2011 [6, p. 31]

Internet telecom services generate the biggest revenues, Internet network equipment and Internet IT services are at the second place [6, p. 51; 7, p. 14]. However, their contribution is much lower than for Internet telecom services. 60% of the revenues in the European Internet industry are coming from telecom services [7, p. xv; 8, p. xiv].

![Figure 5](image3)

**Figure 5** Core Internet Industry Revenues by Segment, EU 27, Billion €, 2010-2014, Source: IDC 2010 [6, p. 51; 7, p. 14]
According to Figure 5 there are five main segments in the Internet economy [8, p. xiii]:

1. Network equipment suppliers
2. Smart handheld devices suppliers
3. Internet-related software and services companies
4. Internet-related telecommunication providers
5. Players in the “web ecosystem”

All these segments are mutually dependent from each other. Communication networks are the enabler to make these contributions possible. Table 1 from [7, pp. 38; 8, p. xvi] shows the determinants for growth and competitiveness for the five segments. In particular, Internet network equipment suppliers are facing economic challenges due to high R&D cost and the dependence from investment decisions of communication service providers. The smart handheld sector is highly competitive.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Determinants for growth and competitiveness</th>
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| Internet network equipment suppliers | • Operating in world market: very high costs to keep up with technological progress (R&D) combined with intense price competition  
• Growth crucially dependent on investment decisions of telecommunication network operators  
• Global players successful manage external growth (purchasing “innovators”) and integrate them |
| Smart handheld devices suppliers    | • European players lag behind international competitors that have managed to tie terminal equipment with exclusive provision of services and applications  
• Likely path-dependency and lock-in effects for end-users due to vendor specificities  
• Entry barriers due to considerable economies of scale regarding R&D, capital requirements and existing patents |
| Internet-related software and services companies | • High economies of scale due to R&D requirements, requirements to keep up with technological/market trends (e.g. cloud) and therefore high capital needs  
• Lack of skilled personnel  
• Lack of venture capital for SMEs  
• Management of external growth |
| Internet-related telecommunication providers | • Significant economies of scale due to high fixed costs of networks (e.g. regarding NGA networks), and therefore high capital needs  
• Intensive price competition on the end user side: low willingness-to-pay for access  
• Lack of competencies to rapidly establish new business models related to the web ecosystem (e.g. regarding content, advertising)  
• Managerial competencies for external growth (incorporation of innovators from outside)  
• Geographical fragmentation in Europe with respect to fixed link and mobile activities  
• Fragmentation of the European markets regarding pan-European business models for multi-nationals |
| Web ecosystem | • High investment needs for physical infrastructure in specific segments leading to capital scarcity (e.g. regarding cloud computing or platform business)  
• Lack of skilled personnel  
• Capability to work efficiently rests on an appropriate access to capital for start-ups  
• High transaction costs due to fragmentation, due to security and privacy rules, language, etc. |

Table 1  Determinants of growth and competitiveness by segment [7, pp. 38; 8, p. xvi]
The following market and technology trends are affecting the Internet industry and have to be considered [8, page xv]:

1. Future Internet industry revenues continue to grow, particularly in the web ecosystem.
2. Increasing demand for ‘big data’ management due to an explosion of data traffic.
3. Growth in cloud computing is four times the growth of IT market as a whole.
4. M2M traffic will increase 40-fold between 2010 and 2015.
5. 64 % of Internet users will be regular social network users in 2015.
6. Tablets and smart phones enable Internet mobility with sophisticated user-interfaces
7. Convergence phenomena regarding telecommunications, mobile services and media will shape the future of the Internet industry.
8. Governance regarding net neutrality may affect investment behaviour and innovation potential.
9. New requirements regarding network security and data protection create opportunities and challenges for the Internet industry.
10. Advertising is becoming a dominant business model in the web ecosystem.

There is a different economic weight of the ICT sector for different economies. In particular Asian economies like Taiwan, Korea, Japan and China are putting a high emphasis of the ICT sector (Figure 6) [9, p. 13]. The US economy is showing a similar percentage value like China. The ICT domain in the EU has a much lower percentage of the overall economy and is in a similar order like India.

![Economic weight of the ICT sector](source)

**Figure 6** Economic weight of the ICT sector. % of sector’s value added in GDP, 2008 or latest data available [9, p. 13]

### 2.3 Overall economic developments

The described developments in Section 2.1 are underlined by huge growth rates of the economies in BRIC countries for example compared to the USA and Germany (Figure 7) [10].
Emerging economies are lacking a modern nationwide infrastructure and competitive industry compared to developed markets. However, the availability of raw material for export enables, e.g. BRIC countries to get the necessary capital to invest in infrastructure and to build up new industries.

These countries are implementing new telecommunication policies, which increasingly require from vendors local manufacturing, development, research and IPR generation in order to catch-up in the world market. Such political developments put pressure on vendors to establish local activities in such markets in order to participate in the economic growth.

In a long-term view the global economy may develop towards a new equilibrium. Around the year 1500 countries like China and India has a bigger share in global economy than Western Europe (Figure 8, [11]). Since the industrial revolution in the 19th century the USA and Western Europe are dominating the global economy. With respect to the huge growth rates in BRIC countries the picture may change again in the long run.

A recent study by the EU Commission on the economic development towards the year 2050 is confirming these trends of shift in the share of global GDP (Gross Domestic product) for different scenarios with respect to 2010 (Figure 9) [12]. Three scenarios were investigated:

- "Nobody cares – standstill in European integration"
- "Under threats – a fragmented Europe"
- "EU Renaissance – further European integration".

On all scenarios highly developed regions like the EU, Japan and the USA will lose share in global GDP and China, India and others will increase their share. Brazil and the Russian Federation will not really benefit from this development. The scenario “EU renaissance” expects a higher share of Europe than the other scenarios.
Therefore, Europe is increasingly becoming dependent on the global market and has to be active with innovative products and solutions.

![Regional shares of the world GDP in 2010 and 2050 in different scenarios](image)

**Figure 9** Share of global GDP in 2010 and 2050 in different scenarios [12]

From the ITU perspective access to broadband communications is essential to achieve the Millennium Development Goals [13, p. 23], which underlines the importance of ICT:

- **End Poverty & Hunger:** A growing body of evidence suggests that broadband can boost GDP and income, helping combat poverty and hunger. Research by the World Bank suggests that a 10% increase in broadband penetration could boost GDP by 1.38% in low- and middle-income countries. Country case studies suggest a strong impact of fixed and/or mobile broadband in individual countries, depending on their economic structure – e.g., in the Philippines.

- **Universal Education:** Governments and NGOs are providing schools with PCs to foster a sound primary education. In Senegal, a survey found 27.8% of school pupils reported they had acquired better knowledge, and 6.5% understood lessons
better with content from ICTs. High-quality electronic content curricula can improve educational outcomes. Portugal and Uruguay have launched programmes to provide students and teachers with laptops as a basic tool for improved education. The Jokko m-education program builds literacy for women and girls through SMS in Senegal.

- **Gender Equality:** In India, the Azim Premji Foundation works using computers as an inducement to keep children in schools, particularly girls, whom they find have 20% lower literacy. Various studies have reported that men and women use ICTs differently, e.g., in Senegal, women use ICTs to access information while men prefer communication with friends and family members. For mobile telephony, GSMA has estimated that closing the mobile gender gap would increase revenues for mobile operators by US$ 13 billion.

- **Child Health:** ChildCount+ is a community health reporting and alerts platform aimed at empowering communities to improve child survival and maternal health. It helps community health extension workers register children under five to monitor their health status, including screening for malnutrition every 90 days, as well as monitoring immunizations, malaria, diarrhoea and pneumonia. It integrates with existing health information systems to help experts analyze data on child health more rapidly to improve treatment.

- **Maternal health:** ChildCount+ registers pregnant mothers and provides support for antenatal care, such as the launch of a software module in Ghana in August 2011 aspiring to reduce mother-to-child transmission of HIV. Hospitals connected via broadband networks are also enabling remote diagnosis and support for maternal health. WE CARE Solar in Nigeria provides healthcare workers and midwives with mobile phones and reliable lighting using solar electricity to facilitate safer deliveries of babies.

- **HIV/AIDS:** Bozza is an online platform which shares content (music, video, poetry etc.) from across Africa. This app uses data-intensive mobile services to raise awareness about AIDS and condom use and create job opportunities in South Africa, Nigeria, Kenya and Tanzania. In South Africa, the Praekelt Foundation uses an open source SMS TxtAlert system to remind HIV patients about appointments and track which patients miss them or ART medication pick-ups. However, the project faces challenges in expanding to clinics without digitized electronic databases outside Johannesburg.

- **Environment:** Smart grids can significantly reduce energy consumption through improved heating, cooling and monitoring technologies. Broadband can reduce energy and water consumption through a range of technologies such as smart transportation and logistics, smart grids and meters, smart buildings, use of video conferencing and dematerialization. Smart use of ICTs can reduce greenhouse gas (GHG) emissions by up to 25%. Mobile technology alone could lower GHGs by 2% by 2020.

- **Partnership:** The benefits of new technologies, especially ICTs, should be made available in cooperation with the private sector. In conjunction with public sector policy leadership, the private sector has driven expansion in the markets for fixed and mobile broadband. The market for mobile broadband has been driven by competition and private sector investment in many countries.
3. Economic impact of the availability of broadband access

3.1 Impact on GDP growth and employment

The Worldbank has studied the impact of broadband communications on economic growth in developed and developing economies for different network systems like fixed networks, mobile communications, Internet and broadband communications [14]. The right hand-side bars in Figure 10 from [14, p. 45] indicate that increased broadband penetration can create GDP growth up to 1.38 per cent points in low- and middle-income economies. In high-income economies the effect is slightly smaller with 1.21 per cent points of GDP growth. However, in the current economic climate with low growth rates such effects would stimulate the global economy significantly. This productivity improvement will increase GDP without increasing resources used in production. For example, the US could increase its GDP by 100 billion $ with an increase of 10 additional broadband lines per 100 individuals (30 million lines).

Similar figures are also reported by the EU Commission that 50 % of economic growth in the European Union is driven by ICT [15].

Usage pattern in low income countries are different, which may lead to different business models. Such systems are helping users to obtain better paid work, help farmers in agriculture, improve health outcomes, survive emergencies and natural disasters, support financial inclusion and low-carbon economy [13, p. 25]. The ITU report [13, pp. 76] provides a detailed summary of impact of the availability of broadband systems on various economies, which also demonstrates the importance of these systems for societal and economic development.

OECD (Organisation for Economic Co-operation and Development) figures also demonstrate the contribution of investment in ICT on GDP growth [16]. Figure 11 shows the impact in percentage points for two time periods. The increased investment and use of ICT in the
period 1995 to 2003, e.g. due to the availability of mobile and wireless communications results in bigger impacts on GDP growth than in the period 1990 to 1995 before.

According to [13, p. 6] and the Boston Consulting group the estimated size of the Internet economy in the G20 countries [17] corresponds to around 2.3 trillion US-$ or 4.1% of GDP in 2010. By 2016 the market size could nearly double to 4.2 trillion US-$. McKinsey estimated that the Internet accounts for 3.4% of total GDP for the G8 countries [18] plus five major economies (Rep. of Korea, Sweden, Brazil, China, and India). ITU does see the following trends which will influence the mobile high-speed future and how will they impact users [13, p. 10]:

- Real-time status updates for objects, as well as people, in a growing ‘Internet of Things’;
- Using location-based services and Global Information Systems (GIS) in many different ways in our lives – for example, to summon taxis, avoid traffic jams, track late buses or stolen cars, locate friends – and ourselves;
- Apps ‘pushing’ out information to users, rather than users searching for and ‘pulling’ in information;
- Sharing our likes and dislikes, resulting in targeted advertising, as well as search results tailored to our personal preferences;
- Better access to healthcare or government services and job opportunities;
- Collaborative crowd-sourcing in authorship, project management, funding relief efforts, generating encyclopaediae or news reporting;
- ‘Collaborative consumption’ or the outsourcing of tasks or household chores for a price;
- Changes to our notions of privacy, or even the demise of privacy?
- Converged cross-platform malware, as well as converged services;
- Storing data in the cloud – you need never again be dependent on your physical device.

These considerations show the importance of the combined capabilities of broadband, reliable and highly available communication networks for the competitiveness of economies. A knowledge-based and service-oriented society needs such networks to be competitive.

Communication networks infrastructure as fixed (optical) and mobile communication systems is the basis for the provision and generation of content and associated applications. Content is responsible for the huge expected traffic growth. Such systems are based to a huge
extend on software. Therefore, the know-how on software technology is essential for Europe to be able to develop future ICT systems. In addition, access to micro- and nanoelectronics as critical components and know-how is strategically important for industry in Europe to be on the forefront of new developments.

The ICT sector has a huge economic impact and a mutual dependency of different sectors like infrastructure, content, software and components as well as system operation. All elements in the value chain are needed to be competitive and successful in the global market.

There are different impacts on the creation of jobs in the domain of communication networks:

- Direct impacts can be seen in maintaining research and development of communication network technology in Europe – in particular for new and future systems – to generate and maintain know-how. With respect to telecommunication policies in other regions of the world like the request for local research, development and manufacturing, and the need to mitigate trade barriers and risk of currency exchange rates there is on one hand strong pressure on industry from Europe to be present in such growth markets (cf. Figure 2); on the other hand the necessary know-how has to be available in Europe, because communication networks are increasingly be used also to operate other critical infrastructures like energy, water, traffic, health etc. Therefore, communication networks are also a critical infrastructure themselves.

- Other direct impacts are the operation of communication networks.

Bigger impacts are expected from secondary effects like the use of deployed broadband communication networks. Investment in broadband communication systems is providing positive effects on economic growth and additional employment [3, p. 4 and 38: 19]. Figures 12 and 13 show the expected impacts for the European mobile industry and the example of Germany. Broadband investments in Germany between 2010 and 2020 will add 170.9 billion € to GDP (Gross Domestic Product) and 968.000 jobs. Similar effects can be expected in other European countries. The revenue of European mobile industry of 174 billion € corresponds to 1 % of total EEA (European Economic Area) GDP. A similar study has been performed already in 2004 by Deutsche Bank [20], which estimated a significant contribution to job creation in Europe by means of mobile communication systems.

![Figure 12](image)

**Figure 12**  Direct and indirect employment created by the European mobile industry, 2010 [3]
The sector is contributing approximately 65 billion € to public funding (taxes) plus additional 18 billion € from related industries (Figure 14) [3, p. 38].

Photonics prepared a market study of the photonics sector and other sectors on the leverage effects of specific technologies. According to Table 2 the photonics and the telecommunication infrastructure sector show the highest leverage effects on economy between the investigated sectors [5, pp. 169]. The definitions of the different parameters are explained in [5, p. 173].
The Digital Agenda Scoreboard of the EU Commission provides data on employment in different ICT sectors (Figure 15) [21]. The overall employment is rather stable between 7.2 to 7.5 million employees in the since 2002. There are some shifts between sectors.

In the telecommunications sector employment decreased since 2002 from about 1.2 million employees to about 1.0 million employees in 2010 (Figure 16) [21]. Reasons for this reduction are changes in technology, reduced maintenance requirements, more software intensive solutions and reduced specialised manufacturing of equipment. The overall employment remains rather stable due to growth in other sectors.

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<tbody>
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<td>Manufacturing</td>
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<td>Manufacture of Electronics and Optical Equipment</td>
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<td>4320</td>
<td>70%</td>
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<td>2448</td>
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<td>31%</td>
<td>27</td>
<td>321</td>
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<td>Manufacturing of Textiles and Clothing</td>
<td>440</td>
<td>2218</td>
<td>11%</td>
<td>48</td>
<td>244</td>
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<td>Media Production and Broadcasting</td>
<td>246</td>
<td>756</td>
<td>60%</td>
<td>159</td>
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<td>Food and Beverage Production</td>
<td>900</td>
<td>4000</td>
<td>17%</td>
<td>152</td>
<td>674</td>
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<td>Printing &amp; Publishing Activities</td>
<td>104</td>
<td>243</td>
<td>49%</td>
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<td>28%</td>
<td>21</td>
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<td>Final Markets</td>
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<td>Medicine &amp; Healthcare Activities</td>
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<td>4</td>
<td>940</td>
<td>71%</td>
<td>3</td>
<td>671</td>
</tr>
<tr>
<td>Electricity Generation &amp; Supply</td>
<td>321</td>
<td>933</td>
<td>34%</td>
<td>108</td>
<td>313</td>
</tr>
<tr>
<td>Construction and Built Environment</td>
<td>1384</td>
<td>13548</td>
<td>10%</td>
<td>138</td>
<td>1355</td>
</tr>
<tr>
<td>Environmental Monitoring and Protection</td>
<td>3</td>
<td>171</td>
<td>35%</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>Recreation, Culture and Education</td>
<td>598</td>
<td>9442</td>
<td>43%</td>
<td>258</td>
<td>4075</td>
</tr>
<tr>
<td>Retail &amp; Services</td>
<td>1892</td>
<td>25722</td>
<td>28%</td>
<td>538</td>
<td>7191</td>
</tr>
<tr>
<td>Total</td>
<td>10371</td>
<td>86307</td>
<td>3613</td>
<td>29614</td>
<td></td>
</tr>
</tbody>
</table>
Employment figures for Germany from Bitkom [22] clearly show the shift between the IT and telecommunications sector. The overall employment increased slightly in the last years. The decrease of employment in the telecommunications sector was overcompensated by the increase in the IT sector (Figure 17), where software and IT services are dominant. Vendors of information technology, telecommunication and Internet services are the second biggest employer in German industry after mechanical engineering and ahead of automotive and electrical engineering.

According to [7, p. xvii; 8, p. xvii] “the growth of the Internet Industry generally leads to an increase in employment in the Internet industry itself. This does not automatically imply an increase in total employment, because many of the new jobs in the Internet sector represent displaced employment. But in the rich ecosystem of highly dynamic and networked SMEs under the Tipping Point scenario, the Internet industry is more likely to produce high-quality employment than in the other two scenarios.” However, both reports indicate that “between 2018 and 2022 the employment effect of the Future Internet is estimated to be negative.”
In many countries the number of ICT employees increased in the last 15 to 20 years (Figure 18) according to OECD statistics [23]. This helped to make societies and economies more efficient and also contributed to economic growth.

**Figure 17** ICT employees in Germany [22]

<table>
<thead>
<tr>
<th>Country</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>835.8</td>
<td>835.2</td>
<td>835.5</td>
<td>847.7</td>
<td>857.7</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>0.5%</td>
<td>0.6%</td>
<td>1.5%</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>Summe ITK + CE</td>
<td>12.1</td>
<td>12.1</td>
<td>10.9</td>
<td>11.1</td>
<td>10.7</td>
</tr>
<tr>
<td>CE</td>
<td>818.8</td>
<td>823.1</td>
<td>824.6</td>
<td>836.6</td>
<td>847.0</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>0.5%</td>
<td>0.6%</td>
<td>1.5%</td>
<td>1.2%</td>
<td></td>
</tr>
<tr>
<td>Informationstechnik</td>
<td>556.6</td>
<td>577.7</td>
<td>587.3</td>
<td>609.2</td>
<td>624.8</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>4.9%</td>
<td>1.7%</td>
<td>3.7%</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>IT-Hardware***</td>
<td>26.3</td>
<td>26.5</td>
<td>23.8</td>
<td>21.0</td>
<td>19.5</td>
</tr>
<tr>
<td>Software &amp; IT-Services</td>
<td>524.3</td>
<td>551.3</td>
<td>563.5</td>
<td>588.2</td>
<td>605.1</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>0.6%</td>
<td>-10.1%</td>
<td>-11.6%</td>
<td>-7.1%</td>
<td></td>
</tr>
<tr>
<td>Telekommunikation</td>
<td>266.3</td>
<td>245.4</td>
<td>237.3</td>
<td>237.4</td>
<td>233.4</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>-8.5%</td>
<td>-3.3%</td>
<td>-4.2%</td>
<td>-2.2%</td>
<td></td>
</tr>
<tr>
<td>TK-Hardware</td>
<td>63.5</td>
<td>57.2</td>
<td>53.6</td>
<td>51.1</td>
<td>50.0</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>-9.9%</td>
<td>-4.3%</td>
<td>-4.9%</td>
<td>-2.1%</td>
<td></td>
</tr>
<tr>
<td>Telekommunikationsdienste</td>
<td>204.6</td>
<td>196.1</td>
<td>183.7</td>
<td>170.4</td>
<td>172.4</td>
</tr>
<tr>
<td><strong>Wachstum</strong></td>
<td>-8.1%</td>
<td>-2.4%</td>
<td>-4.0%</td>
<td>-2.2%</td>
<td></td>
</tr>
</tbody>
</table>

* jeweils zum Jahresende, einschließlich Selbständige
** Angemass

Source: BITKOM, Bundesagentur für Arbeit, Bundesagentur für Arbeit, Statistisches Bundesamt
Stand: Juli 2011

**Figure 18** OECD Key ICT indicators: Share of ICT employment in business sector employment, 1995 and 2008, percentages [23]


### 3.2 Impact on competitiveness

There is a correlation between the availability of broadband access and the global competitiveness index score (Figure 19) [24]. Countries with high penetration rates (top right corner of Figure 19) show much better competitiveness than countries with lower penetration rates (bottom left corner in Figure 19). Therefore, investment in broadband access stimulates the economy.
In order to achieve these benefits it is essential that an investment friendly environment is provided by suitable regulation and under certain conditions by stimulus programs to enable investors to develop a positive business case. Otherwise, such necessary investments will not happen and opportunities for macroeconomic benefits may be missed.

In order to gain from this correlation many countries have set targets for national broadband plans (Figure 20) [13, p. 39].

**Figure 19** Correlation between penetration of fixed broadband and competitiveness
(Source: EC services based on COCOM and WEF) [24]

In order to achieve these benefits it is essential that an investment friendly environment is provided by suitable regulation and under certain conditions by stimulus programs to enable investors to develop a positive business case. Otherwise, such necessary investments will not happen and opportunities for macroeconomic benefits may be missed.

In order to gain from this correlation many countries have set targets for national broadband plans (Figure 20) [13, p. 39].

**Figure 20** Targets set by national broadband plans [13, p. 39]
Source: ITU. Note: Australia's targets specify 100% coverage, with 93% at 100 Mbps and 7% at 12 Mbps. The EU has a dual objective for 2020 of 30 MB for all households & 100 MB for 50% of households.
4. User penetration and traffic growth

According to Figure 2 growth in market size can especially be observed in markets with lower penetration rates compared to Europe. There is still a huge potential to connect underserved regions to communication networks and the global Internet. According to ITU statistics the number of subscribers is growing globally (Figure 21) [25]. The number of fixed telephone lines with low global penetration is decreasing, where the number of mobile subscribers is growing fast globally. With respect to the increase of Internet users also the number of fixed and mobile broadband subscriptions is increasing. Broadband access is growing fast in particular in developed countries. However, globally and also in developing countries the number of subscriptions is increasing. The active mobile broadband subscriptions per 100 inhabitants in Figure 21 explain the different growth rates per market in Figure 2. Europe with already a higher penetration than other regions has less growth potential. Therefore, further growth in the European ICT market can be stimulated by an upgrade of European communication networks to real broadband systems with significantly higher sustainable throughput rates than today and an increased use of communication networks for other critical infrastructures.

**Figure 21** Global availability of ICT development [25]

In addition, the global Internet with more than 2.25 billion users globally (status December 2011) is growing further [26] (Figure 22). This development is requesting reliable and highly available communication networks, which provide the necessary QoS and security in order to support all kinds of Internet based services and applications. European industry is supporting this growth by developing and deploying, e.g. the necessary networks.
Table 3 from [13, p. 12] is summarising broadband access globally including Internet access, fixed and mobile subscriptions and handheld shipments.

<table>
<thead>
<tr>
<th></th>
<th>Total 2011</th>
<th>Broadband Total, 2011</th>
<th>% Global Total high-speed, 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet users</td>
<td>2.26 billion</td>
<td>/-</td>
<td>/-</td>
</tr>
<tr>
<td>Mobile subscriptions</td>
<td>5.97 billion</td>
<td>1.09 billion*</td>
<td>18.3%</td>
</tr>
<tr>
<td>Handset shipments</td>
<td>1.55 billion</td>
<td>491.4 million</td>
<td>31.8%</td>
</tr>
</tbody>
</table>

Table 3 Summary statistics for high-speed connectivity [13, p. 12]

It is expected that data traffic for different traffic types will further grow significantly. Figure 23 from a CISCO study is estimating an exponential growth in the coming years [27; 28].
Figure 24 from an Ericsson study is comparing traffic from voice communication, data traffic from mobile phones and mobile PCs/tablets [13, p. 15]. Voice traffic will nearly remain constant and very small compared to data traffic in future.

![Figure 24 Global mobile traffic: Voice and data, 2010-2017 [13]](image)

Machine-to-Machine communications (M2M) for example in the Internet of Things (IoT) and sensor-based networks is an additional driver for traffic growth. Figure 25 from [8, p. 21] demonstrates an expected 40-fold increase between 2010 and 2015.

![Figure 25 Machine-to-Machine traffic to increase 40-fold between 2010 and 2015 [8]](image)

Drivers of the Future Internet are all kind of services and applications and the variety of devices, which support such services and applications. Communication networks as the interface between user devices and the services and applications domain have to provide the necessary performance and system capacity in order to cope with the expected traffic growth (Figure 26).

In particular video applications are increasing demands for more available bandwidth or data throughput, which may require different distribution channels and systems (Figure 27).
In order to keep pace with the expected traffic growth new and more broadband communication networks need to be developed and deployed in the coming years. Currently, the LTE (Long-Term Evolution) mobile communication system, which is based on a series of European collaborative research projects, is now being globally deployed (Figure 28) [29]. LTE systems require broadband optical and/or microwave links as backbone network. This system is offering more cost-efficient broadband access than fixed networks even in today underserved areas. Figure 21 confirms this observation, which indicates a much stronger growth for mobile broadband than for fixed broadband access. However, barriers for investments, e.g. in the regulatory domain and the lack of sufficiently available frequency spectrum in reasonable frequency bands with good propagation conditions have to be removed to provide a positive business case in such areas and to allow everyone to get access. Figure 29 shows the situation in Europe, where LTE has already been commercially launched in several countries [3, p. 26].
On a global basis broadband is available to a significant extend in developed and industrialised countries. In particular in emerging economies there is a huge potential for further growth (Figure 30) [13, p. 8].
5. Available frequency spectrum

Frequency spectrum for different application areas is identified on global basis by ITU-R World Radiocommunications Conferences (WRC), which usually takes place every three to four years. The next WRC is scheduled for 2015. The allocation of frequency bands is done on national or regional basis. In Europe CEPT as a body of national regulators and the EU Commission is working to harmonise frequency allocations across the EU. Figure 31 shows the evolution of available frequency spectrum in the last WRCs in a simplified form.

![Figure 31](image)

**Figure 31** Available frequency spectrum for mobile communications (Source: ITU-R)

WRC 2007 identified additional frequency bands for mobile and wireless communications (yellow boxes). Extensive work was performed in the preparatory process to estimate frequency spectrum demand based on technology development and market studies. In WRC 2012 mainly the agenda for WRC-15 in the domain of mobile and wireless communications was prepared. However, an agenda item about allocating the band 694-790 MHz for IMT in Region 1 (Africa and Europe) after WRC 2015 was agreed. WRC 2015 will discuss and potentially identify additional frequency spectrum for mobile and wireless communications.

Identified frequency bands have to be made available by national and regional regulators, which usually takes several years – in the order to 8 to 10 years –, where original users may have to be moved to other frequency bands or where primary and secondary frequency use has to be implemented. Means of dynamic and/or cognitive spectrum usage will play an increasing role in future. In summary, frequency spectrum remains a scarce resource.

There are three main challenges with respect to the availability of frequency spectrum:

- Available frequency spectrum is not growing like the traffic volume. This may require in particular smaller cells in densely populated areas (capacity limited) to adapt system capacity to traffic demand, which will result in huge necessary investments mainly for base station/access point sites and the backbone network. The number of sites and system capacity per area unit is increasing with a power of 2 with the reduction of the cell radius.

- In low-densely populated areas, where mainly coverage has to be provided and the system is mainly range but not coverage limited, the number of base station sites should be as small as possible from economic reasons. On the other hand the achievable cell range is decreasing with increasing carrier frequency for a given maximum transmit power of terminal devices. Therefore, more available frequency spectrum at lower frequency bands would be desired from economic reasons to improve the business case for broadband communication in such areas.

- Increased system bandwidth or throughput is also decreasing the cell range and requires more base station sites for full area coverage.

The following eqs. (1) and (2) are summarising these relations. The empirical formula (1) shows the pass loss $L_p$ versus distance and carrier frequency $f$ with distance $d$ between mobile and base station, path loss coefficient $A_f$ (34 to 38 dB depending on environment) for
distance and path loss coefficient $A_f$ (25 to 30 dB depending on environment) for the carrier frequency [30 – 35]:

$$L_p = A_f \cdot \log(d) + A_f \cdot \log(f) + \text{const } .$$

(1)

The number of base station sites $N_{BS}$ is depending on bandwidth $B$ and carrier frequency $f$ as follows:

$$N_{BS} = \left( \frac{d_1}{d_2} \right)^2 = \left( \frac{B_2}{B_1} \right)^{\frac{20}{A_f}} \cdot \left( \frac{f_2}{f_1} \right)^{\frac{2}{A_f}} .$$

(2)

Figure 32 shows that with decreasing carrier frequency the number of sites are decreasing, but with increasing bandwidth the number of sites is increasing. Both parameters have a direct economic impact on the deployment business case due to the number of necessary base station sites and backbone network connections.

![Figure 32](image)

Number of base stations versus carrier frequency

Number of base stations versus bandwidth

**Figure 32** Economic impact of frequency spectrum

Therefore, technical, economic and regulatory issues – with respect to the availability of appropriate frequency bands – have to be considered together in order to provide the requested system performance and to enable a positive business case, which would mobilise the necessary private investment.
6. Economic challenges require an investment-friendly environment

Traffic growth (Section 4) and the economic impact of the available frequency bands (Section 5) create challenges for mobilising the necessary investments for broadband communication networks. For example broadband applications are driving the need for better mobile network quality in terms of throughput rates, latency and efficiency with high user experience.

In order to provide high system capacity, more dense networks need to be deployed compared to voice centric networks. The limited availability of low frequency bands (below 1 GHz) results in the need to deploy smaller cells even in rural areas than needed from capacity reasons in order to meet the coverage requirements. This requires huge investments with long times for return of investment and high capital cost. Infrastructure sharing in such areas is a means to improve the business case for active communication service providers. However, regulatory conditions have to allow that and legal provisions have to be in place that each communication service provider keeps control about its network.

Today’s rate plans based on flat rates result in a low revenue growth of operators even where the traffic is growing much faster (Figure 33). This reduced revenue per bit is requesting significantly lower cost per bit and results in a gap of the business model. Therefore, research on new networking paradigms, a more flexible use of frequency spectrum, radio access technology and backbone networks is needed to provide affordable network deployments for communication service providers and end customers.

![Figure 33](image)

**Figure 33** Economic challenges for mobile broadband network deployment and operation

The ARPU (Average Revenue per User) in Europe is declining per year in the last years significantly due to increased competition and end-customer friendly regulation (Figure 34) [3, p. 35]. This is one of the major reasons for the economic challenges for communication service providers.

![Figure 34](image)

**Figure 34** Evolution of ARPU in Europe [3]
Further challenges for communication service providers are OTT – Over the Top use of networks (e.g. [36]). Communication service providers are challenged by OTT social network messaging service providers:

Ovum “… expects operators to have lost $23 billion (€17.7 billion) in missed SMS revenues in 2012 as a result of competition from OTT players, and predicts losses will grow to a whopping $54 billion” (€41.6 billion) “by 2016. … APAC and European operators will be the most affected by smartphone social messaging services, Ovum warns, and must not ignore OTT messaging activity. “Social messaging is becoming more pervasive, and operators are coming under increased pressure to drive revenues from the messaging component of their communications businesses,” Ovum consumer telecoms analyst Neha Dharia says, adding “Operators need to understand the impact of social messaging apps on consumer behavior, both in terms of changing communication patterns and the impact on SMS revenues, and offer services to suit.” … “OTT players are changing consumers' messaging preferences, and the pressure they are exerting on operators’ messaging services is forcing them to offer increased SMS bundles and to experiment with messaging pricing models, further dampening revenue growth,” Dharia notes. “

Other players like Google, Facebook, Amazon etc. are also using available networks based on flat rate charging models of communication service providers without revenue sharing. ETNO (The European Telecommunications Network Operators' Association) is currently trying to change the overall regulatory conditions in ITU WCIT (World Conference on International Telecommunications (WCIT-12)) [37] to get additional revenues through QoS or paid prioritisation, increased intelligence and information sharing, and pricing strategies that limit the loss of core carrier revenue to OTT services and to ensure revenue sharing with OTT players. According to ETNO OTT players should thereby contribute to the huge investments for broadband network deployments.

There are estimates on the necessary investment in the order of 200 to 300 billion € to provide very high speed broadband coverage (technology independent consideration) in Europe with throughput rates > 100 Mbps [38]. With respect to the economic challenges an investment-friendly environment is needed by appropriate regulatory conditions, suitable financing conditions and potential infrastructure sharing scenarios.

The EU Commission launched in October 2011 a 9.2 billion € program for the time frame 2014 to 2020 as part of the Digital Agenda [39] to fund the roll-out of broadband communication networks under certain conditions. It should complement private investment and public money at local, regional and national level and EU structural or cohesion funds: “The Commission considers that this money could leverage a total of between 50 and 100 billion € of public and private investment – i.e. a substantial proportion of the estimated 270 billion € of broadband investment needed to meet Digital Agenda targets on broadband”[40].
7. Status of broadband deployment in Europe

Statistics on the deployment of broadband communication systems depend on the definition of broadband technology. According to [24] “There is a range of definitions of 'basic' broadband with download speeds from 512 Kbps to 4 Mbps.”

The Major developments are summarised in [24]:

- “The broadband market grew in 2011 but the growth rate continued to slow down. The fixed broadband penetration rate in January 2012 was 27.7% of the population, just 1.3 percentage points up from 26.4% in 2011.
- Despite the slower growth, the EU penetration rate exceeded that of Japan in 2011 for the first time. The difference with the US is 0.5 percentage points behind only.
- Speeds of fixed broadband lines increased significantly in 2011 with almost 50% of all lines providing download speeds of 10 Mbps and above.
- But the take up of fast and ultra-fast broadband, i.e. 30 Mbps and 100 Mbps, is still low with just 7.2% and 1.3% (respectively) of all fixed lines providing those speeds.
- In the second half of 2011, the number of new broadband lines based on xDSL was almost equal to the number of new lines based on alternative technologies sold both by new entrants and incumbents, indicating a shift towards other technologies closely linked to Next Generation Access Networks (NGAs) and capable of providing faster speeds. In 2011 there was an explosion in mobile broadband with penetration reaching 43% of the population in January 2012 from 26.8% in January 2011. This growth was fuelled by handheld devices; there were 35.1 mobile broadband connected handheld devices per 100 citizens in January 2011, up from 19.6 in 2011.
- Data revenues increased by 22.6% in Q3 2011 compared to Q3 2010 in the five largest Western European markets. LTE (Long-term evolution) networks are already available in eight EU Member States and mobile broadband traffic is already more than twice as high as fixed traffic and is expected to grow exponentially in the coming years.”

7.1 Fixed broadband

In the EU average fixed broadband penetration reached in January 2012 27.7 %. However, penetration rates in EU Member States are very different (Figure 35). In particular less developed Member States have significantly lower penetration rates. As shown in Section 3 the availability of broadband networks in such countries will improve economic growth and GDP.

![Fixed broadband penetration, January 2012](Image)

**Figure 35** Fixed broadband penetration rate, January 2012 (Source: Communications Committee) [24]
The available throughput rates are increasing, which are partly exceeding 100 Mbps. In particular in countries, where new networks are being deployed, basically higher throughput rates are becoming available compared to already rather developed countries (Figure 36).

![Figure 36](image)

**Figure 36** Fixed broadband lines in the EU Member States by speed
(Source: Communications Committee) [24]

The average penetration rate in the US is the same like in the EU. However, some countries in Asia exhibit penetration rates, which are much higher than the EU average and which are similar to the most penetrated countries in Europe (Figure 37). From that perspective Europe has to catch up with some major Asian countries.

![Figure 37](image)

**Figure 37** International broadband penetration rates, percentage of population (Source: Communication services based on COCOM and OECD figures) [24]

Japan and Korea are very much advanced in the deployment of FTTx (Fibre To The x) systems, which provide a very powerful broadband network infrastructure (Figure 38) [41]. The US and the EU are significantly behind. However, the business case is rather difficult, if deployments are based on private investments only in particular outside of major cities. Therefore, means have to be developed, which support the faster deployment of FTTx systems by, e.g. infrastructure sharing, potentially the support of an infrastructure provider, incentives for investment and an appropriate regulation.
7.2 Mobile broadband

In mobile communications very high penetration rates have already been achieved. Major market trends are summarised in [24]. The mobile communications market is developing much faster than the fixed network market.

- “Total revenues of the EU mobile sector decreased by 0.8% in 2011.
- Nevertheless, data revenues increased by 22.6% in Q3 2011 compared to Q3 2010 in the five largest Western European markets.
- Europe remained the region with the highest mobile subscription penetration at 127%. Penetration increased by 4.3 percentage points in 2011. Machine-to-Machine SIM cards represented 4.1% of total subscriptions in the EU. Fifty percent of subscriptions were postpaid.
- Market leaders’ and main competitors’ (second largest operators in national markets) market shares have slightly decreased. Mobile Virtual Network Operators (MVNOs) have 4.1% of subscriptions.
- Average Revenue per User declined by 9% in 2010. Average Revenue per Minute stood at EUR 0.11 in 2010.
- Mobile broadband coverage (HSPA) reached 85% in 2010. LTE is already available in eight EU Member States.
- Mobile broadband penetration (all active users) went up to 43% in January 2012 from 26.8% in January 2011.
- Mobile broadband traffic is already more than twice as high as voice traffic and is expected to grow exponentially in the coming years.”

Figure 39 shows the general penetration rates per member states for mobile communications, which are in average beyond 100 %. In particular in new Member States the penetration rates are higher than in mature markets. The driver for this development has been the low availability of fixed network access connections. Mobile networks can be deployed faster and more cost efficient than fixed networks.
In particular in these countries voice traffic is mainly provided by mobile communication systems, where in mature markets fixed networks still dominate voice traffic (Figure 40).

However, broadband mobile broadband penetration rates (Figure 41) are still much lower than the general mobile penetration rates (Figure 39). In this domain highly developed Member States show much higher penetration rates than new Member States. However, the EU average is already quite high. In particular Scandinavian countries have already reached very high broadband mobile penetration rates. Broadband mobile communications has a high potential for further growth in the coming years.
Figure 41  Mobile broadband penetration – all active users (Source: Communications services) [24]
8. Research environment

8.1 Research intensity and basic approach

The ICT sector is one of the most research intensive sectors in industry. The IT components and telecommunications equipment domain spend about 13 to 15% of net sales for R&D, where the relative spending in the US is slightly higher than in Europe (Figure 42) [9, p. 15]. The top R&D investing ICT companies from the EU and the US have similar ICT R&D intensity levels (R&D investment / net sales). However, there are many more US firms than EU firms in the worldwide group of top R&D investing ICT companies.

![Figure 42 R&D intensities (R&D investment / net sales) in EU and US Scoreboard companies (2008) [9, p. 15]](image)

Note: The ICT Scoreboard is an extract of ICT companies from the 2009 EU industrial R&D Scoreboard.

Similar figures are also provided by [6, p. 59] for the IT and Internet domain (Table 4).

![Table 4 R&D investment of selected top 103 Internet suppliers as of turnover, 2009 [6]](image)

In addition, many sectors in the ICT domain and in particular communication networks are highly dependent on global standardisation in order to ensure interoperability of interfaces like for global roaming in mobile communication networks and to ensure economy of scale.
Collaborative research programs support the cooperation of all stakeholder groups such as bigger industry, SMEs, communication service providers, R&D centres and universities in joint projects in order to develop new solutions and systems and to build consensus ahead of future standardisation. Therefore, collaborative projects are part of the overall research and development process in the research community and industry (Figure 43).

Collaboration between competitors in such programs is feasible in the precompetitive phase, where all partners have similar interests to develop new solutions and where IPR portfolios are not build-up (Figure 44). When the development is moving towards standardisation, the common interest may go down and the activity is increasingly becoming competitive. In the product development and market introduction phase cooperation is usually not possible anymore. Therefore, the time window in an early phase of the development is essential to cooperate and to achieve consensus ahead of standardisation. Such consensus solution can then directly be exploited in the standardisation process. This helps to accelerate the standardisation process, shares risks and resources of involved organisations and prepares the ground for future economic success.

Figure 43  Value chain from research to global products

Figure 44  Collaborative research: International consensus building at an early stage
In particular in the domain of mobile communications collaborative research in different framework programs contributed significantly to the development and standardisation of systems like 3G – UMTS, LTE, IMT-Advanced and their further evolution. Research on future radio systems is underway (Figure 45).

![Diagram showing the evolution of mobile communication systems from the 1980s to the 2020s.](image)

**Figure 45** European research programs on mobile and wireless

### 8.2 Collaborative research programs

Europe offers different means for cooperation in funded projects between different stakeholders such as manufacturers, communication service providers, service and content providers, SMEs, universities and R&D centres on EU and national level.

Actual framework programs at EU level are

- **Framework program 6 by the EU Commission (has finished now)** [42]
- **Framework program 7 by the EU Commission** [43]
- **e.g. Eureka clusters (Celtic-Plus, ITEA 2), funding by national administrations** [44; 45]

Currently, the new framework program Horizon 2020 for the financial period 2014 to 2020 is under preparation [46].

Member States are also offering collaborative research programs on national level. Examples are

- **in Germany** [47]
- **in Finland** [48]

Similar programs are also available in other countries.

These activities are supported by European Technology Platforms (ETPs) and Joint Technology Initiatives (JTIs), which are currently under review for the preparation of Horizon 2020:
It is essential for the European economy with respect to growth and jobs and in relation to the global economic environment and competition

- that Horizon 2020 is taking into account the necessary research topics, which are in the interests of European stakeholders,
- that the rules for participation in Horizon 2020 are appropriate with respect to flexibility and administrative overhead and
- that sufficient budget is allocated to Horizon 2020 and in particular to the ICT part in order to support the Lisbon objective to spent 3 % of European GDP for research and innovation.

The budget allocation is not clear and is currently being debated between the EU Commission, EU Parliament and Council. The President of the EU Commission, Mr. José Manuel Durão Barroso, stressed in his speech “State of the Union 2012 Address” on September 12, 2012 the importance of research for recovery of the European economy and as means to overcome the financial crises [57]:

“... And we could go further, with a realistic but yet ambitious European Union budget dedicated to investment, growth and reform. Let's be clear. The European budget is the instrument for investment in Europe and growth in Europe. The Commission and this Parliament, indeed all pro-European forces, because most member States support our proposal, must now stand together in support of the right multi-annual financial framework that will take us to 2020. It will place little burden on Member States, especially with our proposed new own resources system. But it would give a great boost to their economies, their regions, their researchers, their students, their young people who seek employment, or their SMEs. ...  

... It is a budget that will promote a research intensive and innovative Europe through Horizon 2020. Because we need this European scale for research. ...”

8.3 Contributions by the Net!Works ETP

The Net!Works ETP proposed for Horizon 2020 a closer link between different programs for basic research (FET – Future and Emerging technologies), technology-driven and application-driven research in Framework Program 7 and closer to the market activities in the CIP – Competitiveness and Innovation Program. Figure 46 shows the circle of interlinked programs, which should implement the entire chain from basic research towards innovation and commercialisation.
The Commission proposal for Horizon 2020 comprises three priorities, which provide such a linkage between different activities in the research and innovation chain [58 to 61]:

- Excellent Science – Basic research,
- Industrial Leadership – Technology-driven research and
- Societal Challenges – Application-driven research.

The Net!Works ETP is contributing research topics basically to all three priorities in Horizon 2020 to the technical content of the work program of the ongoing Framework Program 7 as well as to the preparation of Horizon 2020 [62]. These topics are identified and supported by the community. The following main areas are proposed:

- For Excellent Science and Industrial Leadership priorities:
  - To overcome the expected spectrum crunch new wireless network topologies, new air interface technologies self-organised networking and cognitive radios should be investigated.
  - In the domain of networks for the next generation of wireless-optics communications research is needed on the physical layer, super broadband systems, cognitive radio over fibre protocol, energy efficient network architecture, operation and control and wireless optics.
  - For architectures and management of future networks the following topics are on the agenda: Cognitive network operation towards a SMART system paradigm, store-forwarding, push and pull, network virtualisation and in-bound cognitive network management.
  - Networks as national critical infrastructures and their implications on security, availability and reliability.
  - Networks for cloud computing and service platforms.

- For the Societal Challenges priority:
  - Smart Cities applications and requirements: Economic, social and privacy implications, security and trust, business models, platformisation, interoperability and open data.
  - E-Government.
  - Health, inclusion and assisted living.
  - Intelligent transportation systems.
  - Smart grids, energy efficiency, and environment.
9. Value generation in Europe

European industry is strong in research, development and the integration of complex systems like communication networks. A widespread and well-established research community in R&D centres and universities is cooperating with industry for knowledge and IPR generation. In addition, communication networks are increasingly based on software technology and software development. However, know-how is also required in hardware and RF design as well as in manufacturing technology for equipment, network planning and operation.

With respect to the fact that communication networks are increasingly regarded as critical infrastructure it is essential for Europe that system research, development, knowledge creation and IPR generation is performed in Europe. All critical parts of system design and manufacturing needs to be done in Europe in order to have full access to the technology.

Many hardware systems are today based on standardised hardware. That allows that parts of manufacturing is being done close to target markets in order to have direct contact to customers, to reduce transportation cost and to mitigate trade barriers and risks of currency exchange rates. However, it is essential that critical parts of communication networks such as system software and special hardware components with the potential to distinguish products from the competition are designed in Europe and provided to the global manufacturing process.

The technology shift from hardware-oriented systems in the past towards software- and signal processing-dominated systems today requires different skills. However, this allows Europe to create higher skilled jobs in this industry as well in the system design as the development of applications. Therefore, the political discussion should not be focused mainly on industrial manufacturing of hardware systems but more on system and solution design. In this domain Europe is in the position to compete on global basis. This requires continuous innovation and significant investment in research, innovation and development to achieve and maintain technology leadership.

In the photonics domain the value chain in Europe is also addressing research, development and manufacturing of basic materials and components and enables a specific manufacturing industry [5, p. 47]. This ensures that access to main technology building blocks is available in Europe.
10. Conclusions

Communication networks are a key enabling technology for basically all sectors of our society and economy. This domain depends on global standards to ensure interoperability and economy of scale for affordable cost. The European ICT market corresponds to about 25% of the global market. The global ICT market is growing, where the market in Europe is stagnating in the last years on high level. In particular the BRIC countries show significant growth rates. Emerging economies are investing to build up an own ICT industry, which is increasing global competition. In particular Asian countries have a bigger share of the ICT domain in their national GDP compared to European economies. The global economy is in a transition phase to a new equilibrium, where the share of Europe in the global GDP will become smaller in the next decades. Different studies have shown that the availability of broadband access stimulates the economy by additional GDP growth and positive effects on employment in particular in secondary sectors for the use of communication technology, application development and service provision. ICT is also an important enabler for productivity growth in all sectors.

Employment in Europe in the ICT sector is rather stable in the last years. However, there are shifts between sectors towards IT and software development at the expense of the telecommunication sector. In total in many countries the workforce in the ICT domain has been increased. There is a direct correlation between the high availability of broadband access and competitiveness of economies. However, this requires an investment friendly environment to mobilise the necessary investment for the deployment of systems. The development towards a competitive European Internet industry will help to support further economic growth and employment in Europe [7].

Europe has already achieved a reasonable penetration of broadband communication systems compared to the world average. The number of users for mobile communications exceeded the number for fixed network users significantly and is still growing. The number of global Internet users is less than 50% of mobile subscribers. It is expected that traffic is growing exponentially in the coming years due to Internet and video applications. This trend results in economic challenges for communication service providers with respect to the limited available frequency spectrum in reasonable bands with good propagation conditions, the user expectations, flat rate charging models and the necessary investment for system deployment. New broadband mobile communication technologies are available and are now being deployed globally like LTE, which will help to solve the challenges. The regulatory environment should support the deployment of broadband networks in order to enable the expected macroeconomic effects on GDP and employment. The EU Commission launched in October 2011 a stimulus package, which however will only support a small part of the necessary investment across Europe. The deployment of broadband access and especially of mobile broadband systems made progress in the EU. However, in the backbone and fibre based systems Europe is lagging behind other regions, which could lead to competitive disadvantages for Europe. Therefore, Europe has to keep pace with other regions in research, innovation and deployment of systems.

The ICT sector is one of the most research intensive sectors. Collaborative research helps to share risk and resources and to build consensus in the precompetitive phase ahead of future standardisation. Europe offers publicly funded collaborative research programs on EU level and on national level. Such programs are supporting the development of new mobile communication systems, optical communications and broadband access. Such investments are required also in future to maintain competitiveness compared to other regions. The preparation of the next EU framework program Horizon 2020 is ongoing. However, there are no final budget allocations available. The NetWorks ETP is contributing to the preparation of work programs based on identified research topics in a wide community from its members.

The value creation in the ICT domain in Europe today is mainly based on system research, innovation and development, knowledge and IPR creation, software and applications development and system operation. There should be the main focus with respect to future activities and investments to maintain and create highly skilled jobs in Europe. Investments in research, innovation and research in Europe are essential to be successful in future global competition.
11. Net!Works profile

Net!Works is the European Technology Platform for communications networks and services. Communications networks enable interaction between users of various types of equipment, either mobile (e.g. mobile phones) or fixed (e.g. PCs); they are the foundation of the Internet. The Net!Works European Technology Platform gathers more than 850 players of the communications networks sector: industry leaders, innovative SMEs, and leading academic institutions. The mission of Net!Works is to strengthen Europe's leadership in networking technology and services so that it best serves Europe's citizens and the European economy.

Bridging the gap between research and innovation and the expectations from the European society is critical. Therefore Net!Works is now committing to interact more with actors outside the research community. Decision makers from the various public authorities in charge of economic development or of local and regional policies, for example, will be asked to provide their views and cooperate.

Further details are available at http://www.networks-etp.eu/.
12. References

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